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ABSTRACT

This paper begins by examining concepts of artificial intelligence (AI) and discusses various definitions of the concept that have been suggested in the literature. The nesting relationship of expert systems within the broader framework of AI is described, and expert systems are characterized as knowledge-based systems (KBS) which attempt to solve problems in the manner that humans do. Problem solving is viewed from the perspective of the library user with emphasis placed on nontraditional approaches to knowledge seeking. Sociological, psychological, and cybernetic systems perspectives are then employed in order to see these information technology developments from a library user's perspective. Finally, KBSs are focused on and criteria for their establishment in libraries are listed. The natural language interface is seen as significant, and the pragmatic features of future library operations such as automated cataloging and the use of expert systems in the answering of reference inquiries, and document and information retrieval are examined. The application of AI in library situations is presumed to offer significant benefits and opportunities. (Author/SD)

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ARTIFICIAL INTELLIGENCE, EXPERT SYSTEMS, NATURAL LANGUAGE INTERFACES, KNOWLEDGE ENGINEERING AND THE LIBRARIAN

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Abstract

Concepts of Artificial Intelligence are examined and definitions elicited. The nesting-relationship of expert systems within the broader framework of AI is pointed out. Expert systems are defined as Knowledge-Based Systems which attempt to solve problems in the way human experts do. Problem solving is viewed from the viewpoint of the library user with emphasis being placed on non-traditional approaches to knowledge seeking. Sociological, psychological and cybernetic/system perspectives are employed in order to see these IT developments from a library user's viewpoint. Finally, KBS are focussed on and the criteria are listed for their establishment, in libraries. The natural language interface is seen as significant and the pragmatic features of future library operations such as automatic cataloguing and the use of expert systems in the answering of reference enquiries and document/knowledge retrieval are examined. The application of AI to libraries is seen to offer immense opportunities.

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Defining machine or Artificial Intelligence is difficult:

Smith (32) simply sees Artificial Intelligence as efforts aimed at studying and mechanizing information-processing tasks which normally require human intelligence. Minsky (30) seems to take the same approach "..artificial intelligence is the science of making machines do things that people need intelligence to do." Here the emphasis is on the machine and its capacity to solve problems.

Nilsson (24) on the other hand takes a much broader view stating that "AI has embraced the larger scientific goal of constructing and information processing theory of intelligence. If such a science of intelligence could be developed, it could guide the design

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of intelligent machines as well as explicate intelligent behaviour as it occurs in humans and other animals."

Feigenbaum (31) too thinks of AI as "... not primarily oriented towards technology but rather, towards investigating the nature of intelligence as information processing, whether the intelligence is expressed by man or machine."

"Basic to both (approaches) are principles of how information is recognized, acquired, arranged to create order from disorder, and retrieved. Co-existing concepts are the inference of relations between seemingly unrelated ideas, reasoning and the generation of new knowledge" (17).

Perhaps Avron Barr (3) summarizes most appropriately for librarians these diverse viewpoints when he sees in AI that part of computer-science which is concerned with creating and studying computer programs which exhibit behavioural characteristics identified as intelligence in human behaviour: knowing, reasoning, learning, problem solving, language understanding etc.

Barr, together with many AI researchers sees, learning ability to be a key to successful machine intelligence. For this the computer would need to develop two potentials:

- the ability to recognize a problem that it has already solved (the 'bored' computer concept)

- the capability to select relevant facts.

Given this focus one must agree with Mason (21) who states that "one can imagine potentially astounding implications for libraries from ... the development of Artificial Intelligence, current availability, the relationship of AI to microcomputer systems and how it may be used by information professionals."

Barr (3) also emphasises "knowing". The knowledge issues of heuristics have dominated AI research for the past decade. The basic issues may be broadly categorized as (a) the representation and (b) the processing problems:

- how can knowledge be represented in a machine

- how can this knowledge be processed and communicated.

AI researchers have become increasingly uncomfortable with the standard methods for representing knowledge epitomised by symbolic logic. Non-standard ('commonsense') logic, "frames" and "scripts" are relatively elaborate data structures designed to relate different facts to one another in ways which are similar to human expectations.

Thus, "frames" are collections of facts about a particular subject. A library "frame" for example would have categories for facts about libraries, such as type (public, academic,

special, etc), budgets, numbers of items in the collection and so on" (21).

The greatest interest in AI over the next few years is expected to be in three categories: expert systems, natural language interfaces and visual recognition. Expert systems and natural language interfaces are of most interest to information professionals. This is underlined by Belkin and Vickery(7) who point out that "question-answering as well as expert systems employ many techniques developed by AI, techniques of search, knowledge representation and natural language processing".

An Expert System is a computer program "capable of performing tasks ordinarily requiring a well trained specialist for a given domain"(4). When presented with a series of facts, an expert system follows a set of rules and reaches conclusions.

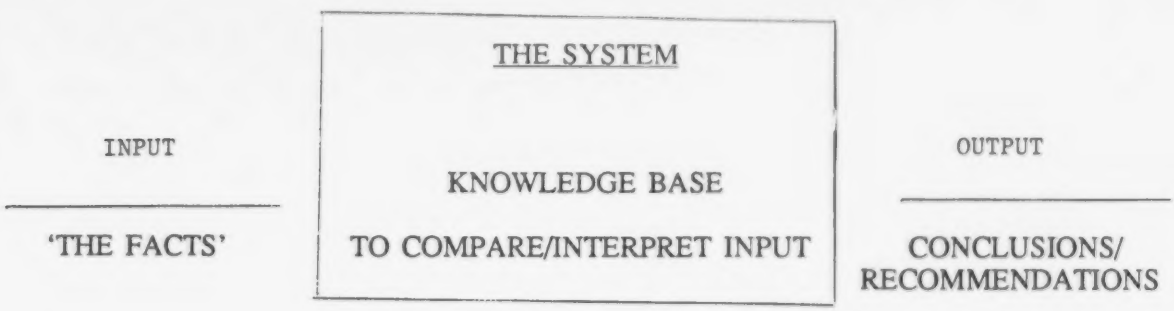
Three criteria distinguish expert system from other computer programs: "problem solving using uncertain or judgemental knowledge; explanation of the reasoning process and the ability to absorb and utilize ne information to improve problem solving capabilities" (26).

The system consists of 3 parts:

- a database (facts)

- a knowledge base (eg a set of rules by which to compare and interpret facts)

- an "inference engine" which applies this knowledge to act on the situation - specific facts which are fed into the machine.



Thus an Expert System is a knowledge based system which attempts to solve problems. They are called knowledge-based because their performance depends on the use of facts and heuristics provided by experts. In the complex and specialised world of today, human expertise about diverse subjects, scientific, economic, social and political, plays an important role. We rely heavily on the human expert's ability to identify and synthesize factors to form judgements and decisions. We use years of our experience to gain expertise in some specific narrow area and they apply this specialization in problem-

solving. One of the most important characteristics of expert systems is the way they search for solutions. They are characterized by interactive dialogues between men and machines, dialogues that are an integral part of the system. Typically the user interacts with an expert system in a form of consultation dialogue, in the same way as he would interact with the human expert: thoroughly explaining his problem, defining the uncertainty as to how to deal with the problem and discussing possible solutions. Expert systems can be viewed as intermediaries between human users and human experts, the human expert giving his expertise and hence being in a knowledge-imparting mode with the system and the human user taking advice from the system and hence interacting with the system in a consultation mode. Expert systems are well established in many areas of knowledge and progressive libraries are beginning to acknowledge this. Thus "some libraries have made interactive fiction programs available for the public, stories whose plot and outcome depend on choices made by users. The continued evolution of expert systems may give libraries the opportunity to offer not only interactive but also proactive services that search knowledgebases and provide the information even before the user is aware that it is needed. Libraries face ... challenges in assuring equity of access and personal privacy as this evolution continues" (21). An expert system designed to simulate the reference transaction by supplying a list of appropriate sources in response to a question is being developed at the Drexel College of Information Studies. The sources cited will also be ranked by number according to their likelihood of answering the question. Not only librarians but users themselves will be able to use this directly (12). Researchers at the University of Udine in Italy are developing an expert intermediary system for bibliographical retrieval systems which use a natural language interface for end users (28).

To summarise, Barr, Bennett and Clancey (4) state "A key idea in our current approach to building expert systems is that these programs should not only be able to apply the corpus of expert knowledge to specific problems but they should also be able to interact with the users and experts just as humans do when they learn, explain and teach what they know. These social interactions-learning from experts, explaining one's reasoning and teaching what one knows - are essential dimensions of human knowledge. They are functional to the nature of intelligence as expert-level problem-solving and they have changed our ideas about representation and about knowledge". Just as the aim of library automation is not to eliminate the human factor but to increase productivity in terms of quality and quantity, so too the expert system should reduce drudgery in repetitive tasks and take advantage of the categorized knowledge of experts in order to improve a library's performance. As Forsyth (13) has stated an expert system should "cover a wider range of problems, deliver more accurate solutions, obtain answers more cheaply and simplify codified knowledge."

Most of the development of expert systems is limited to special purpose computers that use the LISP (LIST Processing) or PROLOG symbolic programming languages. LISP is the language of choice for most U.S. researchers; Prolog is used by most of the rest of the world, including Japan in its fifth generation computer efforts.

> "The goal of research and development in Natural Language Interfaces is to permit human operators to communicate with computers using a more human like language... For the library community the beginnings of a natural language

interface to DIALOG exist through the Menlo Corporation's microcomputer program INSEARCH. The Institute of Scientific Information's (ISI) SCIMATE, and other programs which act as 'front ends' to information services" (21).

Waltz et al (38) have suggested that the importance and economic impact of natural language (NL) processing is two-fold:

- NL can enable computers to interact with users in ordinary language and therefore it can make computer power available to segments of the population that are unable or unwilling to learn one of the formal languages usually required for interaction with computers.

- NL can increase knowledge productivity in providing mechanical means for manipulating knowledge expressed as natural language text.

Grishman (14) in reviewing natural language processing research concludes his discussion by introducing the possibility of linking these two areas of activity with the recording of information through man-machine conversation. In this way, natural language processing research may affect storage and retrieval of large bodies of information and libraries must be a prime target for such developments. Marc (20) too in speaking of expert systems notes that they "offer simulated reasoning which models what the user wants and suggests what can be done to solve the problem preferably in simple natural language which can be easily understood".

Implicit in everything stated about AI, expert systems and natural language interfaces, is meeting the information needs of the user. Before moving on to knowledge engineering in a little more depth we must look at the user. The traditional view of information seeking behaviour by the user is that of undifferentiated information need. It is assumed that the user arrives at the 'information system' with a 'need' for some (more or less) well-specified information. One major alternative approach to the traditional view adopted by librarians is that of considering the user of information systems as part of a complex of other systems all of which affect that person's information behaviour. The first major proponents of this view in library and information science were Paisley (21) and Allen (1). Allen, (2) indeed managed to operationalize a part of this view within large scale empirical studies of information behaviour.

The major intellectual influence on this school of thought was the work of Talcott Parsons who proposed a system-theoretic sociology. The point of this school is that human behaviour is influenced by a large number of social systems; that is that a human being is a member of a number of different systems and that consideration of human behaviour in any one of these systems cannot be divorced from the influence of the other systems upon that behaviour. Thus, information behaviour (and perhaps information used) is dependent not only upon the information system of which the user is a part but also upon the user's cultural system, political system, membership group, reference group, invisible college, formal organization, working team, legal/economic system and of course her or his own psychological system.

At about the same time as these sociological approaches toward information behaviour were gaining prominence a somewhat different psychological approach to information behaviour was being introduced in library and information science. Whilst Taylor (36) originated this approach, Wersing (40, 39) developed it further. This was done by constructing a cybernetic model of human behaviour based on the work of Stachowiak (34) in which a person's actions are founded on internal model of, inter alia, her or his environment, knowledge, situation and goals, the last two expressed primarily as events with associated certainty values. A 'problematic situation' (40) arises when a person's internal models of environment are insufficient for that individual to attain appropriate goals. Information-seeking behaviour occurs when internal models are insufficient for the individual to act in accordance with his/her own goals. Belkin (5,6,7,8) attempted to represent those cognitive structures. This explicitly cognitive, internal and individual-based view of information behaviour becomes directly related to problems which the user is attempting to resolve. Wersing has suggested that the best way to view information behaviour is as an aspect of human behaviour in general, in particular in terms of information as supportive of problem management. Thus information related to human behaviour explicitly within the realm of problem management when problem is taken in a very wide sense, that of contradiction between aspirations (goals, needs) and resources or capabilities, at levels ranging from internal individual states to social conflict. In such a sense much of human behaviour is concerned with problem management, and the role of information is to be supportive in the appropriate management of information.

How then will expert or knowledge-based systems introduced above affect the librarians and in general how are we to approach knowledge engineering? Montgomery (23) notes that information processing technology is used currently in the management of many aspects of the library function including the important one of establishing and promulgating the indexing parameters for material. In addition, through modern communications, reference librarians can access data-bases, chiefly of the bibliographic kind, as we have seen at Drexel, which significantly improve their ability to track down written material from a large range of potential sources. Walker and Janes (37) propose a theory in which an expert system can be used to model the behaviour, heuristics and expert knowledge of an on-line search intermediary. Thus, a knowledge-based system (KBS) utilising proper knowledge engineering concepts which seeks to mimic (and improve upon) the capabilities of intelligent humans, needs to include the components listed below. However, as we have seen, a significant additional component of a knowledge-based system, is that of the language interface to a system, Quinlan (29). Some KBS have the capability of interpreting requests for the answers to problems from users, of providing answers to the user in a domain-specific subset of natural language and, finally, of explaining to the user the reasons why the system had arrived at a given conclusion.

In summary such a KBS would now consist of:

- A knowledge representation mechanism for appropriate static knowledge

- Rules

- Procedures

- An inference mechanism for deriving conclusions from the knowledge base not directly represented.

- A language interface to receive requests, furnish answers and provide explanations.

What direct implications does this have for librarians? We are in an era when attempts are being increasingly made to consolidate, catalogue and codify our knowledge so that we go forward from our current knowledge base to tackle more complex problems in the future. The cataloging and codifying may not and possibly should not follow traditional approaches.

Expert systems represent one manifestation of the consolidation process. We see that we do not have to hold every possible fact in our data-base; instead we hold essential facts and also general rules or methods which enable us to derive other facts as the need arises. Not all problems are capable of solution with the current or foreseeable KBSs. But such systems will do for much expert knowledge what the printing press did for the spoken word of the savants: expert knowledge will soon be made more widely available by accessing a library. Such a capability will have an enormous impact upon the relevance of libraries. There is little difference between the processes necessary for using a book and using an expert system for some specific problem domains. The parts of KBS which relate to the comprehension and generation of Natural Language will enable librarians to interact with data bases more simply than ever before and perhaps do completely automatic cataloguing. It is already possible as we have seen to build an Expert System to emulate the work of a Reference Librarian in some limited sphere of discourse and to guide a potential borrower through on line interaction to the location of documents or other required materials. This frees the reference staff to act at a higher level of professional proficiency acting as coordinator and exploiter of all appropriate information resources including KBS expert systems.

"Interaction with information retrieval systems can be very complicated since each vendor has its own searching protocol and each database is structured differently. Traditionally, intermediaries have been the largest users of most commercial bibliographic systems but this process may change somewhat through expert front-end systems. If the system is developed properly, end-users will be more likely to do their own searching since feedback could be provide in natural language to assist in improving the search strategy. Some front end systems are being developed to simplify searching for end-users, but other systems are being designed for experienced searchers to further increase their efficiency"(18). It should be stressed that there is a strong indication that in expert systems future users will be able to conduct comprehensive and successful online literature searches without the aid of a librarian or information specialist (25). Smith and Chignell (33) are developing a prototype expert system for using Chemical Abstracts Service's CAS Online which will allow end-users to perform high-quality searches without the aid of an intermediary.

Existing systems in the United States include CyFr developed at Yale to read text and answer questions about the database, PA-PERCHASE, a self-service facility which requires no formal instruction, user manual, or trained human intermediary, thereby reducing the cost of searching; FRED, which fulfills connection, communication and centralized processing functions as a front end system for INFOS developed by Obermeier and Cooper (25). "INFOS will capture the expertise of the information specialists, particularly in their capacity as information counselors ... it will capture knowledge in a specific domain while at the same time operating as an interface and as an aid in problem solving". IIDA which instructs users and provides them with diagnostics; and OL'SAM which provides front ends to data-bases. In addition, the National Library of Medicine is developing the Hepatitis Knowledge Base which provides answers to questions in the form of authoritative statements, thereby bypassing the lengthy reference retrieval, document acquisition and perusal cycle. (19,9,22,15,35). As Obermeier and Cooper have pointed out (25) an information specialist functions on many different levels when responding to a request for information.

Some progress has been made in developing expert systems for traditional library work, the rule-based activities of cataloguing and classification seem particularly worthy of attention. In the area of cataloguing, two approaches seem feasible: a first-step person - the machine interface where intellectual effort is divided between the human intermediary and the support system; and an expert system with full cataloguing capability linked to an electronic publishing system so that as text is generated online, it can be passed through the cataloguing process without intellectual input from humans. A study at Exeter University in the UK is investigating the use of AACR2 and the MARC Manual as sources of rules for a cataloguing knowledge base as well as natural language data querying, intellectual storage and retrieval from the database (11).

An expert system classification system can also be envisaged with a natural language exchange which could sift, weigh and rank order terms of greatest use and relevance before conducting a search through its knowledge base to match retrained terms with subdivisions. This exercise would be followed by a rationalization exercise before the optimal notation is decided upon (41).

Doubtless, other rule-based tasks could be enhanced by the expert system approach including that of indexing and abstracting. Jones (16) summarises the large number of library-oriented functions which lend themselves to this technology. "Some of the major functions which are possible candidates include: information retrieval; the selection or recommendation of the correct classification codes for items being catalogued, the development and implementation of specialised classification schemes, the improvement of domain specific subject thesauri, the assigning of subject headings to items being catalogued; expert systems to help end users with online catalogues; front end systems for online handbooks, encyclopaedias, journals, or other data sources and the development of decision support systems to help library administrators with strategic planning based on data collected and analyzed from online catalogues, circulation, acquisition and serials require a deal of time and effort to develop."

Less than 4 years ago, Clarke and Cronin (10) looking at expert systems in the library were able to say that "one of the major developmental problems relating to expert systems is the apparent lack of interest in library/information applications among AI researchers". Today this is no longer clearly the case. Just one year later in fact Machovec (18) noted that "Although research in AI and expert systems have been primarily considered in the theoretical realm of computer scientists, the implications and impact of this research are likely to make significant inroads on libraries during the next two decades. Expert systems will plan an important role in using information retrieval systems, decision support systems for library managers, cataloguing, indexing and several other related areas."

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